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# CLIMATIC AND HUMAN-RELATED FACTORS IN THE DEVELOPMENT OF RELIEF (BASED ON HISTORICAL DOCUMENTS PERTAINING TO THE MARGINAL ZONE OF THE CARPATHIAN FOOTHILLS)

*Abstract*: The study was carried out in the Carpathian Foothills and aimed to assess the effects of both the climatic change and human activity on the agricultural landscape. An array of methods applied included ground relief mapping, as well as valley deposit and historical document analyses. As a result the magnitude of agricultural landscape transformations was assessed and periods of intensified geomorphic processes identified. It was found that at the turn of the 18th and 19th centuries foothill slopes developed rapidly which manifested itself in intensive build-up of deluvial and proluvial material in the valley bottoms. During the little Ice Age, the expansion of arable land at the cost of woodland exposed the area of study to sheet-wash, rill erosion and gullying.

*Keywords*: land use change, antropopressure, historical documents and geomorphic processes.

The wide spread of agricultural landscapes and their significance for humans make understanding of their ground-relief evolution particularly interesting and important (IGPB Report 1995, 1996). According to UN estimates more than 50 per cent of the World's population make their living in agriculture-related jobs and roughly 30 per cent of the globe's landmass (excluding the Antarctic) is covered by farmland (Stanford, Moran 1977). Geomorphic processes that occur in such landscapes are determined by their natural environment and by human activity. Understanding key factors shaping the types and intensity of geomorphic processes, based on ground relief analysis, is tremendously important for making projections on how agricultural areas will react to the growing human pressure and in assessing ecosystem productivity.

The area of research, i.e. the marginal zone of the Carpathian Foothills between the rivers Raba and Uszwica (40 km east of Cracow), has been agriculturally cultivated since the Neolithic period (Cetera, Okoński 1993, 1994, 1995). It is a typical example of an area shaped by human activity. What is more, by combining favourable climate, accessible ground relief and good soils it has potential for further extensive farming and as such is an interesting area where to forecast the effects of agricultural activity.

The fact that an intensive human pressure that dates back to the agricultural colonisation in the early Middle Ages occurred at the same time as the climatic change makes the assessment climatic impact on the natural environment during the last 1000 years a still unresolved issue (Klimek 1987, 1999). The turn of 18th and 19th centuries is a particularly interesting period marked by disruption in river channel stability, higher surface sheet-wash, mass movements and changes to the composition of plant species. In this relation the following questions should be asked. Was it caused by human activity? Or perhaps by natural forces? The split views represented in literature, i.e. that the climate (Little Ice Age) or changes to agricultural methods (introduction of new crops and forest clearing) were crucial for geomorphic processes, indeed require a final verdict.

Answers to the above mentioned questions may be sought in the sediments, landforms and in historical documents. The research project conducted in the Carpathian Foothills aimed primarily to understand relief changes as a reaction to human economic activity. It is a well-known fact that phases of fluvial activity related to climatic change and human activity are imprinted both in the valley-bottom relief and in the alluvia. The first phase of the study when land relief and covers were mapped was followed by historical source analysis in the second phase. Thus, a basis was created for correlation of granularity analysis and alluvia dating with the results of archaeological and historical research. Then the results were compared to previous research conducted in the upper Vistula valley and its Carpathian tributaries (Kalicki 1997; Kalicki, Pietrzak 1999). An investigation was made into the sediment structure of the Stara Rzeka valley bed and into the accumulation fan at the outlet of the Kubaleniec valley. The structure of the sediments appeared to reflect subsequent settlement phases (5300-4300 BC, 1st – 4th c., 11th – 15th c. and 18th – 19th c.) and the agricultural use of these areas (Bluszcz, Pietrzak 1998a, b). The easily distinguishable lamination does point to sheet-wash origin of those structures. Material had been accumulated within marshy valley bottoms covered with grass during periods of intensified sheet-wash that carried material down the arable slopes. However, both the uniform granularity of the deposited material which was a result of its similar characteristics in the source, i.e. dusty slope covers, and the mode of deposition prevented more detailed conclusions to be drawn. Nevertheless, historical sources yielded certain information that suggested that the deposits had been made in historical times. Similarities between the loess fluvial and deluvial covers in the threshold and in other European agricultural areas with loess-based soils suggest that the conditions and geomorphic processes under which these covers formed were also similar. J. De Ploey (1985) explained the lack of stratification and lamination of an old colluvium with the domination of splash and sheet-wash and associated the cross-laminations and scour-and-fill structures with the domination of rill erosion and gullying within slopes extensively used as arable land. B.Van Vliet-Lanoe et al. (1992) identified three phases of intensified down-cutting in western Europe in historical times (800-1400, 1500-1750, 1900-on) and stressed the significance of the little ice age for the increased soil erosion intensity.

The full extent of the roles played by humans and by climatic change in relief transformations were only possible thanks to historical documents. The latter were analysed particularly for the data on population, modes of economic management and land management, as well as on the prevailing dominant natural environment.

The *Chronicles of the Benedictine Nuns* found in the archives of the Benedictine convent at Staniątki (20 km east of Cracow) proved to be exceptionally valuable sources of information on the Carpathian Foothills. The Chronicles include not only copies of property donations for the convent, but also descriptions of weather phenomena, natural calamities and social relationships prevailing in the countryside. Land records, known as *metryka józefińska* and *metryka franciszkańska*, cover the mode and intensity of farming, as well as numerous descriptions of geomorphic conditions and processes at the turn of 18th and 19th centuries. They were the official property descriptions kept by the Austrians for taxation purposes. Now they are to be found in the Ukrainian Central Historical Archives in Lviv.

The investigation concluded that during the last millennium the evolution of relief in the Carpathian Foothills was related to stages of the local agricultural development. Between the 10th and 15th centuries the ratio of forest and meadow area to arable land area was reversed thus leading to an intensified rill erosion and sheet-wash, as well as to the initiation of gullying. The permanent transformation of a woodland and agricultural landscape into purely agricultural landscape with isolated forest areas resulted in the adaptation of geo-ecosystems to the new conditions.

The period that began in the 15th century and lasted until the turn of the 18$^{th}$ and 19th centuries featured a further gradual expansion of arable land at a cost of forestland but without disrupting the balance of the entire environmental and cultural conditions.

The end of the 18th and the beginning of the 19th centuries was marked by a rapid rate of transformation caused by human economic pressure on the environment. Consequences of forest cutting, river engineering, further subdivision of agricultural land and an increased road network density were reflected both in the landscape and in lower agricultural productivity. The largest change in the structure of land use was caused by the increase in the built-up area to 13 per cent at the cost of the same proportion of arable land being lost. Mountain and hill slopes were the one element of the landscape that underwent the most dynamic transformation as a result of the changed extent of woodland, arable land, as well as the deeply incised country roads. Intensification of geomorphic processes was triggered chiefly by an increased rate of deforestation accompanied by a boost in the area of arable land, road network density and river engineering. Each of those factors had its impact on the land relief. Initially the disruption of river stability resulted in river channels growing shallow and wide and then, during the 20th century, in a renewed rapid deepening (Klimek 1987, Łajczak 1988, 1995 and Wyżga 1991). The increased road network density increased the rate at which water run through catchment basins, intensified the drainage of roadside areas and direct supply of material into river channels.

These intensified geomorphic processes experienced by the Carpathian Foothills at the turn of the 18th and 19th centuries as a result of rainfall combined with high

proportion of arable land in the total slope-side area, produced a high rate of deluvial and proluvial material build-up in the valley beds. This is a conclusion that may be derived from the two land registers mentioned earlier, i.e. the *metryka franciszkańska* and *metryka józefińska*. They provide descriptions of land relief, practical soil quality and most of all the results of geomorphic processes that hamper farming. Among natural factors mentioned at the time as limiting crop productivity were: high slope gradients *"steep fields in a hilly area"*, numerous gullies and trenches within slopes *"the arable fields lie so far behind huge gullies that the fertiliser cannot be brought there otherwise than with a cart pulled by eight to ten oxen, finding which impossible the owners sow oats for two consecutive years and idle the fields for another two years"* and water and air properties of the soils adverse for farming *"the hard and carbonate soil does not lend itself well to cultivation either during a dry summer, as it gets parched and cracked-up, or during a wet one for its excessive water-holding capacity"*. Separately treated are those effects of geomorphic processes that prevent efficient cultivation: torrential rainfall *"the ground will not hold the fertiliser because of the intensive rainfall"*, intensity of runoff and sheet-wash *"every rain brings sand from the hills.... every rainfall used to flood meadows with sand so that grass is only cut once [a year – transl.]"*, fluvial processes *"it is flooded and waterlogged by the Raba river several times [a year – transl.]*, eolian processes *"since 1800, 2500 fathoms of sandy land went out of use for the winds"*, animals *"good and average meadows: grass grows short and they are normally ruined by moles"*.

Land registers provided detailed of land-use structure in the marginal zone of the Carpathian Foothills during the period in question. Arable land occupied 61% of the total area, meadows - 11%, pastures, shrubs, orchards and idle land - 11% and forests - 17%. Some 21% of agricultural land was classified as better quality (in permanent cultivation), 37% as average quality and 42% of the area to the worst category which was most difficult to cultivate and hence was frequently set aside (for comparison, land set aside accounted for almost 30% of agricultural land in Galicia, or the Austrian portion of Poland). The view that arable land played a significant role in the expansion of sheet-wash and mass movement may only be correct with relation to a limited area. At the time, the main crops included wheat, rye and oats; on less fertile soils these were mainly rye and oats, less barley. The opinions found in publications on the subject that the introduction of potatoes as a crop influenced slope processes cannot be justified (data for the entire Galicia indicates that ca. 1.5% of all arable land was occupied by potato fields). Normally, slopes were cultivated along the fall line. The average holding had 5 to 10 hectares of land. Subdivision of land (increase in the number of population and inheritance) caused the number of plots to grow from 103 plots per sq. km in 1787 to 110 plots per sq. km in 1820. The numerous terraces and agricultural escarpments at the extant boundaries of historical plots play the role of local denudation bases and contribute to a continuous petrifying of the local relief contrasts.

Historical sources provide ample evidence that the mode of farming at the marginal zone of the Carpathian Foothills had not been changed anywhere near the turn of the 18th and 19th centuries. Therefore, it seems appropriate to conclude that since significantly large effects of geomorphic processes were recorded for the period

in question and agricultural management did not undergo major changes then these effects must have been conditioned by the climate. While this conclusion is made with regards to the marginal zone of the Carpathian Foothills, it is fair to suppose, in the light of the professional literature, that also in other parts of Poland the increased intensity of geomorphic processes was mainly caused by the increased precipitation at the time when the area of woodland shrunk (Pietrzak 2000). It seems that the type and intensity of geomorphic processes are conditioned not just by land-use structure but also by the rate at which such structure changes. Indeed, it would be difficult to find any other period in history when land use structure would change so rapidly. When referring to geomorphic activity of humans, M. Klimaszewski (1978) observes: "*humans create new forms, transform the old ones and create conditions which may speed up or slow down geomorphic activity of external and internal forces*". In the 18th and 19th centuries, the rate at which forests were cut down, the excessive forest exploitation and the increase of arable land area all provided perfect conditions for an increased intensity of sheet-wash, rill erosion and gullying. The direct impulse that triggered the increased action of external forces was provided by the climatic changes of the Little Ice Age such as unstable precipitation and the state of the land.

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